

wheat

A highly important cereal crop of the genus *Triticum* of the grass family, Gramineae, wheat was probably first cultivated in the Euphrates Valley nearly 9,000 years ago. Since that time wheat has played an important part in the feeding of people and animals. The most important species of wheat include common wheat, *T. vulgare*, used in BREAD; durum wheat, *T. durum*, used in such pasta products as spaghetti and macaroni; club wheat, *T. compactum*, used in cakes and pastries; and Polish wheat, *T. polonicum*.

Most of the approximately 30 species of wheat have hollow stems. The leaves are long and narrow. The head is characterized by flowers numbering 20 to 100 and occurring in spikelets. Fertilization of the flowers produces grain. A deep crease extends the length of a kernel, and many short hairs occur on the kernel's small end. The entire kernel is surrounded by the pericarp, or outer bran, which is difficult to remove and represents 15 percent of the kernel. The rest of the kernel is composed of endosperm (83 percent) and germ (1.5 percent). The object of FLOUR milling is to separate these constituents.

CULTIVATION

The wheat plant adapts to a wide range of environmental conditions, from those in the Arctic Circle to those in the tropics. It is best cultivated in temperate areas with 250 to 750 mm (10 to 30 in) of yearly rainfall. Wheat cultivation spread throughout the world with the advent of trade. It was unknown in the Western Hemisphere until the Spanish brought it to the Americas in 1519. For thousands of years the sickle remained the common method for cutting wheat, and threshing was done by beating to separate the kernels from the hulls. When the reaper was invented about 1830, mechanical operations were used for cutting and threshing. Today self-propelled combines are common.

Depending on variety, planting time, and environment, commercial wheats are classified as hard or soft, spring or winter, white or red, or durum wheat (the latter is usually marketed separately from other types). After the wheat seed is planted, it starts to absorb moisture and swell, and soon the pericarp, located at the germ end, ruptures. The primary bud emerges, then lateral rootlets. The plant pushes up through the soil, soon forming foliage. Leaves grow from the base area near the stem; therefore, grazing or cutting does not prevent renewed growth. Winter wheat can thus be pastured without harming the plant.

As the plant grows, short stems form branches, called tillers, close to the ground; these become straw. The head begins to develop and emerges from the leaf sheath, flowering takes place, and fertilization occurs. Some flowers are sterile. Environmental hazards to the wheat plant are drought, freezing temperatures, and wind erosion.

Wheat is subject to numerous diseases and insects, such as grasshoppers and locusts, Hessian flies, green bugs, army worms, mosaics, smuts, rusts, and weevils. Plant breeding research has eliminated or drastically reduced damage caused by many diseases and insects.

BREEDING

Active wheat breeding programs in many worldwide research centers have sought higher yields, improved baking quality, and enhanced nutrition. The first big stride in yield potential occurred with the introduction of semidwarf varieties responsive to fertilizer applications and insensitive to length of day. Semidwarf wheat, because of its shorter straw, is less vulnerable to lodging, being beaten down by wind and rain.

Improving the chemical and physical properties of the wheat kernel depends on the plant breeder's skill and knowledge in manipulating the genes controlling these characteristics. Much progress has been made by transferring genes, but in the process the difficulties and limitations of the theoretical potentials have become evident. Developing hybrid wheat has been slow and far less spectacular than developing hybrid corn. This is partly because wheat quality is a major concern; increased yields are not the only objective.

The hard-wheat breeding programs have two objectives: to increase protein content and to enhance protein quality. Until recently, improved yields have decreased protein content; however, newer varieties are high yielding and maintain high protein content as well. The nutritive value of wheat protein does not differ much among varieties as measured by amino acid analysis. Lysine is a limiting amino acid; consequently, efforts have been directed to producing varieties with a higher lysine content.

Wheat and other cereal grains do not contain appreciable amounts of vitamins A, D, or C, but do contribute

minerals and the vitamins thiamine, riboflavin, and niacin. Breeding programs can be expected eventually to improve the total nutritive value of wheat.

PRODUCTION

The means used to prepare the seed bed, seed it, and harvest the wheat differ according to country and location and can vary from manual labor to massive equipment use. Land is prepared for sowing by plowing, disking, harrowing, and drilling. Whenever environmental conditions permit, seeding occurs in the fall so that the root system can develop and use the warmth, moisture, and sunlight in the spring. Moisture in semiarid regions is conserved by allowing the land to remain idle for one entire growing season. This practice is called fallowing. The physical and chemical properties of wheat differ from those of other cereal grains because wheat proteins can form gluten, a necessary substance in bread making. Gluten-rich flour develops into a cohesive dough that retains fermentation gases, thus causing the dough to rise. Gluten development in wheat differs in different varieties and is altered by soil and growing conditions. Wheats therefore differ in quality from season to season and place to place. Environmental factors usually determine wheat quality.

World wheat production totaled almost 600 million metric tons (661 million U.S. tons) annually in the early 1990s. The two largest wheat producers were China and the United States. Other major growers included India, France, Canada, Turkey, and Australia. (The republics of Ukraine, Russia, and Kazakhstan were the prime contributors to production in the former USSR, once the world's leading wheat grower.) The United States and the 12-nation European Community each held about 30 percent of the wheat export market.

MARKETING

Storage of harvested wheat often occurs on the farm and can vary from crude pits to earthen containers to straw, wood, steel, or cement storage structures. Grain can be handled by a number of means, varying from manual labor with sacks or baskets to sophisticated equipment including automatic truck or car dumps and various conveyor systems for the rapid movement of large quantities of grain. After harvest, wheat is moved from areas of production to areas of utilization and then to regions of consumption. Depending on shipping costs and availability, transportation may be by wagon, truck, railroad, barge, or ship. Wheat is moved to the local elevator as the first collection point, then shipped to terminal elevators, which in turn supply the processors or ship to export locations. Flour mills usually are located near centers of population because wheat can be shipped at less cost than can the commodities manufactured from wheat. Different kinds of flour are required by the baking industries; consequently, wheat of different qualities must be segregated for delivery to mills for manufacturing special products.

Wheat is a commodity often in surplus supply, a situation creating international marketing problems because prices, in years of plentiful supply, can fall below the costs of production. Compounding the problem is the practice of many countries—the United States and the European Community nations are prominent among them—of providing export subsidies in order to lower wheat prices for the international market.

USES

Wheat ground into flour and made into baked products is the form in which most wheat is consumed; however, pasta products are popular and represent an expanding market. Durum wheat is especially suitable for pasta. Puffed, flaked, and rolled wheat is used in breakfast foods. A wheat food product called bulgur is prepared by cooking, dehydrating, and peeling wheat. It resembles rice in appearance but not in eating qualities. Processed wheat germ is used in various specialty foods and to produce vitamin E. Wheat-germ meal has a protein content of about 29 percent.

Wheat for animal feed or pet foods is restricted because it is usually higher priced than other cereal grains of comparable nutritive value. Much wheat, however, is fed to animals in regions throughout the world where no distinction is made between food and feed grains. The by-products of the flour milling operations are bran, shorts, germ, and low-grade flour usually marketed as feed. Monosodium glutamate, a common condiment, is derived from gluten.

Industrial plants use several methods to separate gluten and starch from wheat. The proteins must not be denatured during drying because this action destroys the vital dough-forming properties. Gluten is mainly used in the bread-baking industry. Dried gluten contains 75 percent to 85 percent protein, 5 percent to 10 percent lipids, and some starch. In addition to being used in baking, gluten is hydrolized for use as meat extenders, meat substitutes, pet foods, and flavors for soups and sauces.

When gluten is separated from wheat, the marketing of starch becomes necessary. Wheat starch cannot easily compete with other sources of starch, such as corn or cassava, because of the more expensive processing and difficulties in obtaining pure starch. It can, however, be used for essentially all usual starch purposes. Research programs are attempting to find additional industrial uses for wheat.

J. A. Shellenberger

Bibliography: Bajaj, Y. P. ed., *Wheat* (1991); Chapman, G. P. ed., *Grass Evolution and Domestication* (1992); Hanson, Haldore, and Borlaug, Norman, *Wheat in the Third World* (1982); Heyne, E. G. ed., *Wheat and Wheat Improvement*, 2d ed. (1987); Klippart, John H., *The Wheat Plant* (1980); Matz, S. P., *The Chemistry and Technology of Cereals as Food and Feed*, 2d ed. (1991); Pomeranz, Y., *Wheat Is Unique* (1989); Stoskopf, Neil, *Cereal Grain Crops* (1985).